Resilience Enhancements in the Sahel: Analyzing the Impact of the Great Green Wall Initiative

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Abstract

This thesis investigates the factors influencing resilience enhancements in the Sahel region with the implementation of the Great Green Wall Initiative. By performing a statistical analysis using the Spearman correlation test on secondary data, this research identified the characteristics of improving resilience across different countries in the region. The results show a positive relationship between the level of funding and efforts in land restoration. Higher urbanization rates are associated with lower planted seedling numbers, but the relationship is modest. HDI was not significantly correlated with improvements in resilience. Those who have actively engaged in international projects tend to have better outcomes regarding resilience. Support is further provided in national policies and governance frameworks, where countries with higher governance structures and political freedom seem to be doing well regarding resilience initiatives. Nonetheless, there are still challenges of inadequate funding and technical weaknesses within monitoring systems. This study demonstrates that strong governance and international cooperation are pivotal in enhancing resilience in the Sahel. Future research should focus on the long-term impacts, the role of traditional knowledge, and specific policy measures to further understand and improve resilience efforts in the region.

Contents

1. Introduction

1.1 Background

The Sahara Desert is slowly encroaching on the Sahel region of Africa due to desertification. According to the UNCCD, desertification involves "land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variation and human activity" (UNCCD, 1994). This concern became prominent during the droughts of the 1970s and 1980s. The Sahel, located just south of the Sahara, includes countries like Senegal, Mauritania, Mali, Burkina Faso, Niger, Nigeria, Chad, Sudan, South Sudan, Ethiopia, and Djibouti Figure 1. Liu and Xue (2020) report that the Sahara is expanding by 11,000 km² each year, threatening the Sahel, where many countries rank in the bottom 30 on the Human Development Index (HDI). This expansion disrupts livelihoods, particularly in agriculture and cattle herding, as 90% of jobs are in the informal economy (Ministerie van Algemene Zaken, 2020; Blanchet, 2021). Desertification exacerbates issues like poverty, food insecurity, and displacement, hindering sustainable development. To combat this, the Great Green Wall (GGW) initiative was launched in 2007, aiming to plant a wall of trees across Africa, from Dakar to Djibouti.

The GGW has been researched before. Some research focuses on the success of the GGW in a couple of countries. However, D'Odorico et al. (2013) points out that limited understanding exists regarding the effects of desertification on a socio-economic scale. Nevertheless, the declining livelihoods caused by reduced crop yields, repeated extreme weather events and political instability could lead to significant human migrations on a large scale, carrying substantial environmental, socio-economic, and political implications (Birkmann et al., 2022). However, more research needs to be done on the differences in resilience enhancements between countries thus far. This research will be helpful to better understand how to increase resilience for the entire Great Green Wall (GGW) region.

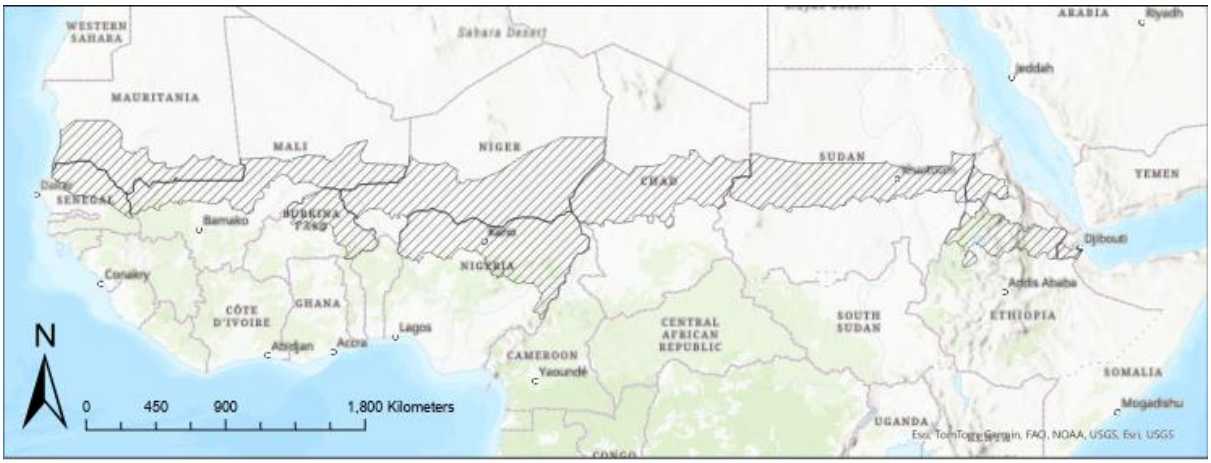

Figure 1 The Sahel GGW intervention area in this study

1.2 Research Problem

The main purpose of this research is to identify different levels of resilience enhancements that exist between countries that are participating in the Great Green Wall project. The necessity of this research involves recognizing the ongoing and significant challenges posed by desertification and climate change in the Sahel region. While previous research has explored various aspects of the Great Green Wall (GGW) initiative, there has not been a comprehensive study that integrates geographic, socioeconomic, and political factors to understand resilience enhancements This research aims to increase the understanding of the factors influencing resilience enhancements. To achieve this the following main research question is proposed.

- What are the *factors that are influencing* resilience enhancements between the different countries in the GGW intervention region of Africa?

The secondary research questions below have been derived from our main research question.

- In what ways do national policies and governance frameworks impact the implementation of resilience improvements in countries within the GGW intervention area?
- Additionally, how do traditional knowledge and local community involvement contribute to resilience-enhancing initiatives within the Great Green Wall project?
- Furthermore, how do socioeconomic factors including resource accessibility and poverty levels impact the effectiveness of resilience enhancements in different nations?
- Lastly, what are the obstacles and difficulties countries encounter in implementing resilience measures, and how do these vary across the GGW intervention area?

1.3 Thesis structure

This thesis is structured to present the research and findings in a linear fashion

Chapter 2 discusses the theoretical framework, focusing on the GGW's ecological and socio-economic aspects.

Chapter 3 outlines the research methodology, including the Spearman correlation test used to analyze relationships between variables.

Chapter 4 presents the data analysis results, examining the links between various factors.

Chapter 5 discusses the findings, their policy implications, and concludes with key insights and recommendations for future research.

2. Theoretical framework

2.1 Components of the Theoretical Framework

There is a lack of effort in measuring technical success and broader impacts over time when it comes to impact measures for the Great Green Wall Initiative (GGWI). The current measures are generally short-term and focus on the planting process, such as the number of trees planted, farmers trained, and labourers hired (United Nations Convention to Combat Desertification, 2020). However, despite this, the original vision of the GGWI still shapes its promotion and how the implementing governments think. The goal remains the same - to "green" Africa from Senegal to Djibouti - but the GGW has added new initiatives to reduce

socio-economic vulnerability at the same time. This dual objective reflects the complex and evolving nature of the initiative (Turner et al., 2021, 2023). The theoretical framework for assessing the GGW must consider multiple dimensions to fully capture its impacts. By focusing on education, infrastructure, biodiversity, sustainable land management, policy and governance, and socio-economic factors, this framework will provide a comprehensive approach to evaluate the initiative's success and long-term sustainability.

2.2 Dependent variable

Land restoration.

Land restoration is crucial for combating desertification, as it helps mitigate climate change by reducing emissions and increasing carbon capture, while also bolstering climate change adaptation (Gichuki et al., 2019). It's important to note that various types of trees provide different benefits to the environment. To ensure the long-term sustainability of these benefits, planting strategies for initiatives such as the GGW should aim for a diverse range of tree species. This approach can also have a positive impact on soil biodiversity and activity, as noted by Lange et al. in 2015. In the context of the GGW intervention area, there is an impressive case of building resilience through the natural generation of trees by farmers in the Maradi and Zinder areas of Niger. This initiative turned the situation around from a downward spiral of poverty, decreased crop productivity, and increased food insecurity in the mid-1980s to a positive development trajectory with more trees, better livelihood outcomes, and improved drought resilience, as documented by Sendzimir et al. in 2011. Moreover, it does not only have a positive implementation of climate change but also brings economic benefits. Every dollar invested in land restoration can amount to 30 dollars in economic benefits (United Nations Environment Programme, 2021). In this study, our focus on land restoration will concentrate on the production of seedlings and plants to enhance crop yields and profits, as well as reforestation. However, there has been a transition from solely planting trees to more varied land use and restoration systems. At present, no data has been provided on this shift (United Nations Convention to Combat Desertification, 2020).

2.3 Independent variables

Urbanization

Infrastructure developments that create new roads, public transport routes, telecommunication installations, and internet access can contribute to increasing resilience. This is especially true by providing access to previously isolated rural areas, markets, and destinations. This was highlighted in a study by Goffner et al. in 2019. Public infrastructure can provide greater income opportunities for the poorest rural populations. Access to such infrastructure can have a direct or indirect impact on their income (Satish, 2007). Agricultural surplus is needed to support infrastructure, which can, in turn, further support agriculture, and this positive feedback can only take off if the required population are there, and the climate is sufficiently reliable to maintain accumulated surpluses from year to year (Kirkby, 2021). Population density is considered to be a measure of land utilization and it is assumed that less land is likely to be converted to tree plantations in areas with higher densities (Zomer et al., 2008). Urbanization can result in further desertification, as the conversion of agricultural land to accommodate growing population centers increases the pressure on the remaining agricultural areas. This worsens the desertification process in regions that are already prone to vulnerability, due to soil erosion and salinization caused by agricultural activities (Portnov & Safriel, 2004).

GGW resource allocation

Resource allocation theory focuses on how limited resources can be distributed efficiently to achieve maximum benefit (Gupta, 2023). In the context of the Great Green Wall (GGW)

initiative, this theory helps in understanding how financial resources are allocated across the vast and diverse intervention areas spanning multiple countries in Africa. The bigger the intervention area per country the more land restoration has to be done the higher the costs. However, the costs per hectare of labor for reforestation decrease per hectare from €1660 per hectare to €170 per 1000 hectare (Andres et al., 2024). Furthermore, this study expects that the larger intervention areas will also give the highest land restoration outcomes no research could be found on this.

HDI

There is little empirical evidence of the social benefits of programs that sustainable land management practices can lead to increased food production and income through direct job creation or the production of timber and non-timber products such as fruit, gum Arabic, and medicinals. Furthermore, it is essential to consider social costs, such as enclosing areas for afforestation that local communities rely on, according to Turner et al. (2023). Moreover, higher HDI levels can contribute to the success of the GGW project by providing regions with greater resilience, capacity, investment, education, awareness, health, and well-being. These factors create an enabling environment for effective project implementation, leading to more significant and sustainable impacts on land restoration, community development, and environmental conservation. Higher HDI has a significant overlap with Sustainable Development Goals according to De Neve and Sachs (2020).

Governance

The nature of the Great Green Wall (GGW) as a pan-African initiative involving national institutions for implementation shapes the governance context. Effective governance is crucial for the successful implementation of the GGW, as it involves coordinating efforts across multiple countries, each with its own political dynamics and institutional structures. This can foster broad participation and learning, which are among the identified principles for resilience, according to Goffner et al. in 2019. The political situation in the countries participating in the GGW significantly influences the initiative's implementation and success. Several factors related to the political context can impact governance and policy effectiveness. Political stability is a crucial factor for the successful implementation of long-term projects like the GGW. Countries with stable political environments are more likely to have consistent policies and support for the GGW initiatives. In contrast, regions experiencing political instability, conflict, or frequent changes in government may face disruptions that hinder progress (Shepherd, n.d.). This shows that political turmoil in countries like Mali and Sudan can pose significant challenges to project continuity and resource allocation. By building strong international partnerships, aligning policies, and empowering local communities, the GGW can maximize its impact and achieve long-term success in combating desertification, restoring degraded lands, and promoting sustainable development across the African continent (O'Connor & Ford, 2014). Finally, Countries that are actively engaged in international projects tend to exhibit higher levels of local resilience efforts (Kim & Doerfel, 2024).

2.2 Conceptual Model

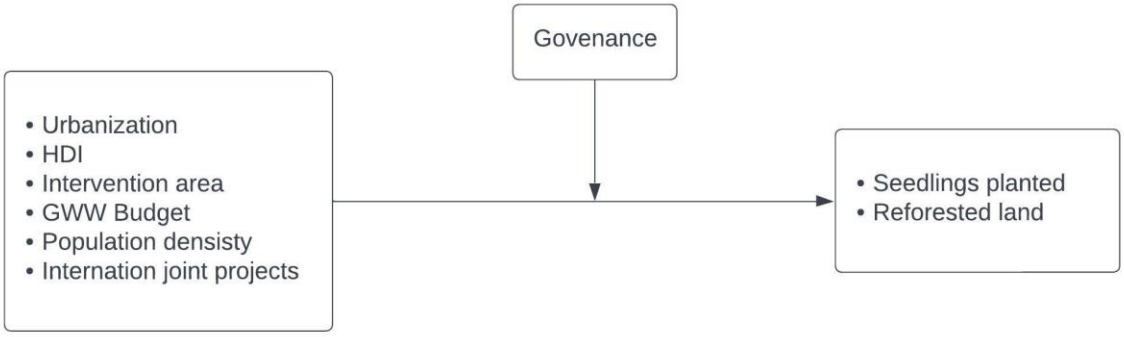

Figure 2 Conceptual model

This section introduces the conceptual model, as shown in Figure 2. Some main elements and linkages of this model include country-specific factors: political systems, Human Development Index (HDI), population density, and urbanization rates and their impacts on the policies/enhancements of resilience. The model thus emphasizes that, although resilience policies are imperative, the related effectiveness is highly determined by these contextual factors. This model, therefore, emphasizes complexity in trying to increases resilience and how approaches should be tailor-made, considering the unique socio-economic and political contexts in each of the countries within the GGW intervention area.

3. Methodology

This research aims to investigate the factors influencing resilience enhancements across different countries in the GGW intervention area of Africa, with a focus on socioeconomic factors such as resource accessibility and poverty levels. The methodology involves a comprehensive data collection approach, using both UN sources like the United Nations Development Programme (UNDP), United Nations Convention to Combat Desertification (UNCDD) and Food and Agriculture Organization (FAO), and third-party sources such as the World Bank and the African Development Bank for data on resilience improvements.

Most of the data is collected from UN sources this data was chosen due to the UN's credible, reliable, and wide data collection and standardization processes. Especially the "The Great Green Wall Implementation Status And Way Ahead To 2030" report from 2020 which gives the most up-to-date data on the project status of all the countries. Unfortunately, there are no more recent data available. Other data will be acquired from World Bank which organization is known for its comprehensive economic data. The data from the UN and the World Bank is imported into Excel, it's organized, cleaned, and analyzed using Excel's tools. Then, visualizations are made by graphs to make trends and patterns easier to understand.

To analyze the relationship between various factors and land restoration efforts in countries participating in the Great Green Wall (GGW) project, this study employed the following statistical methodology:

Spearman correlation was chosen because it measures the strength and direction of association between two ranked variables, making it suitable for non-parametric data.

Data was collected for the following variables:

- Planted Seedlings: The number of seedlings planted in each country.

- Hectares Reforested: The area reforested in each country, measured in hectares.
- Human Development Index (HDI): The HDI score for each country.
- Urbanization: The percentage of the population living in urban areas in each country.
- GGW Budget: The budget allocated for the GGW project in each country.
- GGW Intervention Area: The intervention area covered by the GGW project in each country.
- International Projects: The number of international projects in each country.
- Political System Score: The score associated with the political system of each country.

The collected data was integrated into a single DataFrame for analysis. Missing values were handled by dropping the rows with missing values where necessary.

For each pair of variables, we calculated the Spearman correlation coefficient and the corresponding p-value. The Spearman correlation coefficient (ρ) indicates the strength and direction of the relationship:

- A ρ close to +1 indicates a strong positive correlation.
- A ρ close to -1 indicates a strong negative correlation.
- A ρ close to 0 indicates no correlation. The p-value determines the statistical significance of the observed correlation. A p-value less than 0.05 typically indicates statistical significance.

4. Results

The following section presents the findings from our analysis of the GGW) initiative's impact on resilience across the various countries in the GGW area. Table 1 provides an overview of the factors being analyzed, including political systems, GGW intervention areas, the number of plants and seedlings, reforested land, GGW budget, Human Development Index (HDI), GDP per capita, population density, urbanization percentage, and total international projects. These factors collectively represent the status and progress of GGW efforts in different countries and form the basis for understanding the initiative's effectiveness and challenges.

Through examining these variables, we aim to identify patterns and relationships that influence the success of resilience projects. The data highlights the diverse political, economic, and social contexts within which the GGW operates, offering insights into how these factors contribute to or inhibit the initiative's goals. Through this analysis, we strive to uncover actionable insights that can inform future strategies and enhance the overall impact of the GGW initiative in combating desertification and promoting sustainable development in the GGW area.

Following the overview of individual factors, this section explores the interactions between key variables such as political systems, intervention areas, reforested land, socioeconomic indicators, and international involvement. By analyzing these combinations, this researches aims to uncover patterns and relationships that provide deeper insights into the success and challenges of GGW project.

Country	Political system	GGW intervention area	Plants and seedlings	Reforested land	GGW Budget	HDI	GDP per capita	Population density	Urbanization %	Total International projects
Burkina Faso	Coup	133000	16600	20383	€ 32,963,611.00	0.438	€ 1,704.97	85	35	6
Chad	Coup	30000	1100	994	€ 5,556,070.00	0.394	€ 1,393.56	14.5	36	3
Mali	Coup	444000	135	6297	€ 26,781,016.00	0.41	€ 1,651.94	19.1	45	4
Mauritania	Hybrid Regime	16500	2000		€ 10,638,413.00	0.54	€ 2,065.15	4.7	49	2
Niger	Coup	473000	146000	364615	€ 78,068,240.00	0.394	€ 1,007.72	21.5	22	6
Nigeria	Hybrid Regime	174000	7600	2801	€ 2,149,642.00	0.548	€ 5,070.49	245.7	58	4
Senegal	Hybrid Regime	8000	18000	72452	€ 18,300,000.00	0.517	€ 2,660.68	92.3	51	5
Sudan	Coup	23000	1900	85000	€ 19,730,000.00	0.516		25.8	48	2
South Sudan	Civil war					0.381		17.5		0
Djibouti	Authoritarian	3400		90	€ 5,556,070.00	0.515	€ 3,623.06	49	83	1
Ethiopia	Authoritarian	132000	5500000	151448	€ 2,149,642.00	0.492	€ 2,289.41	112.1	22	5
Eritrea	Authoritarian	124000	128800			0.493	€ 643.79	31	28	1

Table 1 An overview of the factors that represent the status of the GGW and other socioeconomic indicators

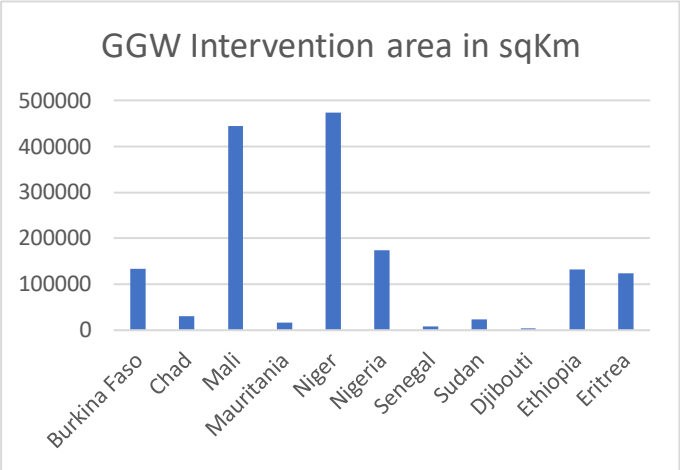

Figure 3 Total intervention area in sqKm per country within the GGW

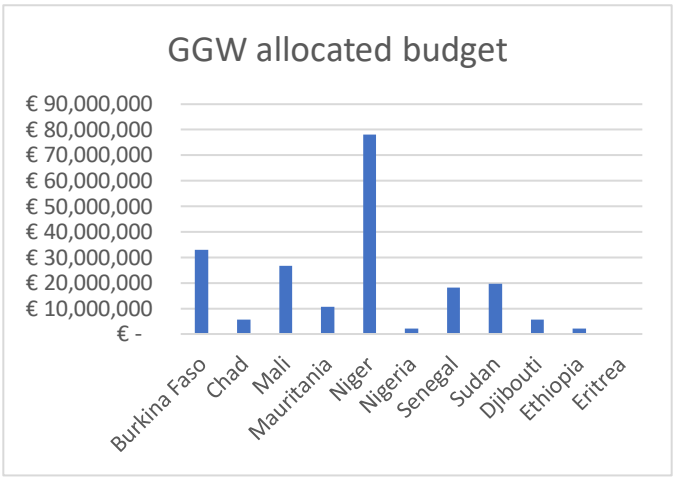

Figure 4 Budget per country for the GGW project in euro's

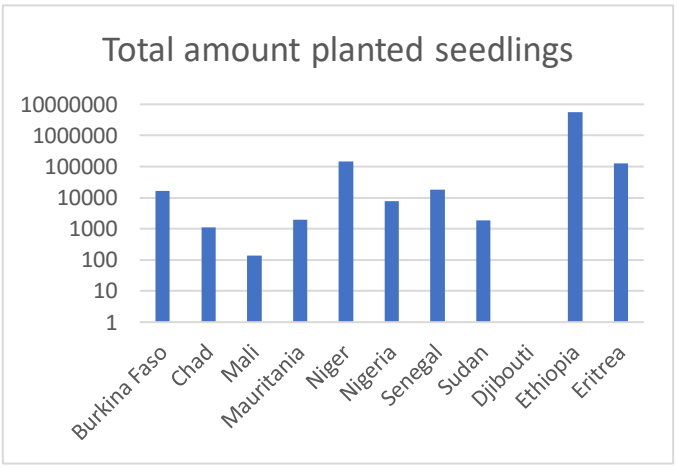

Figure 5 Total amount of planted seedlings per country in an algorithmic scale.

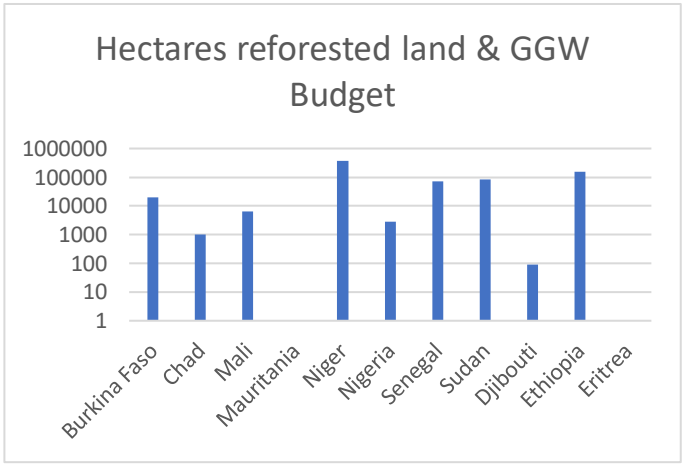

Figure 6 Total amount of hectares reforested per country in an algorithmic scale.

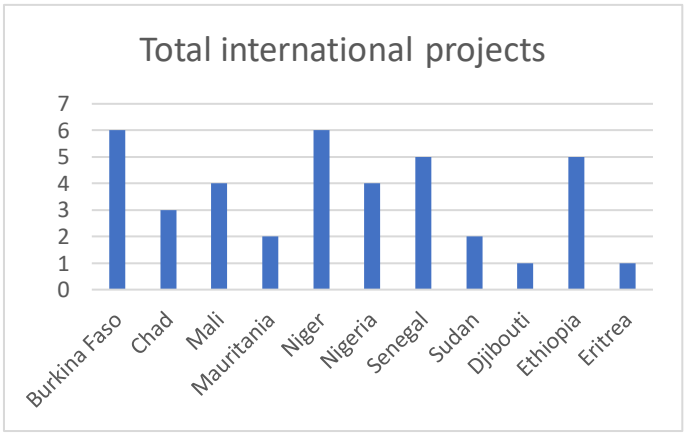

Figure 7 Total international projects per country

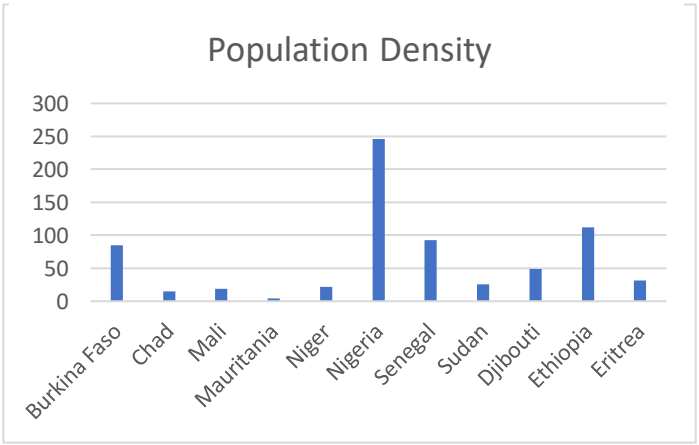

Figure 8 Population Density

The effect of Urbanization on Seedlings planted & Hectares reforested.

In (Figure 9) we can see those countries with lower urbanization rates, like Niger and Ethiopia, tend to have planted a higher number of seedlings. These countries often have more available land and lower land costs, facilitating large-scale reforestation efforts. On the other hand, countries with higher urbanization rates, such as Nigeria and Djibouti, tend to plant fewer seedlings. The higher cost and limited availability of land in urban areas restrict the scale of reforestation projects. Whilst this phenomenon has not widely been researched one of the only ones is that according to Qiu et al. (2022) regions with higher urbanization rates have food production as a higher need than reforestation efforts. To explore the relationships between urbanization and both planted seedlings and hectares reforested, we employed the Spearman rank correlation coefficient. Figure 10 illustrates this relationship between urbanization (%) and two key reforestation metrics: the number of planted seedlings (circles) and the hectares reforested (crosses) across various countries involved in the Great Green Wall (GGW) initiative. The analysis reveals a significant negative relationship between urbanization and the number of planted seedlings, with a Spearman correlation coefficient of -0.651 and a p-value of 0.030. This indicates that as urbanization increases, the number of planted seedlings tends to decrease significantly. Conversely, the relationship between urbanization and hectares reforested is weaker, with a Spearman correlation coefficient of -0.396 and a p-value of 0.228, suggesting no statistically significant correlation. Thus, while urbanization appears to impact the number of seedlings planted, its effect on hectares reforested is less clear.

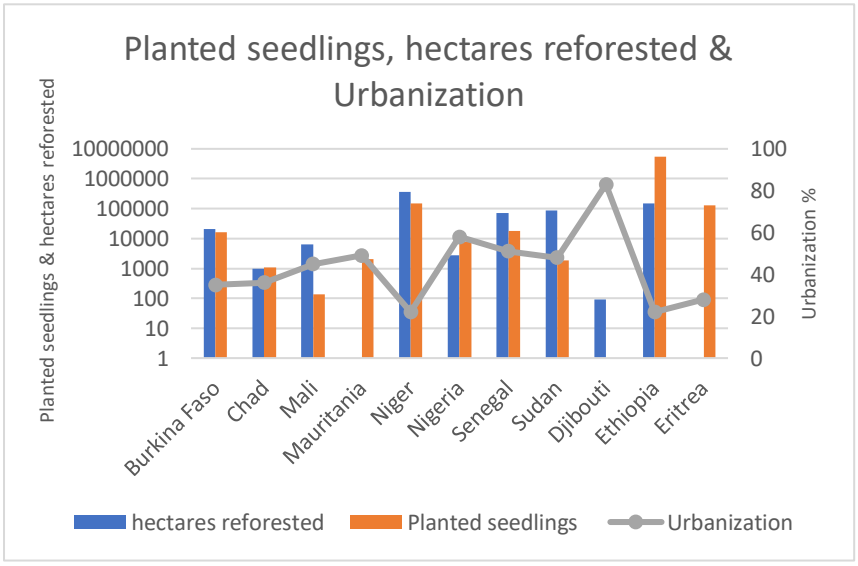

Figure 9 Planted seedlings, hectares reforested & Urbanization % per country

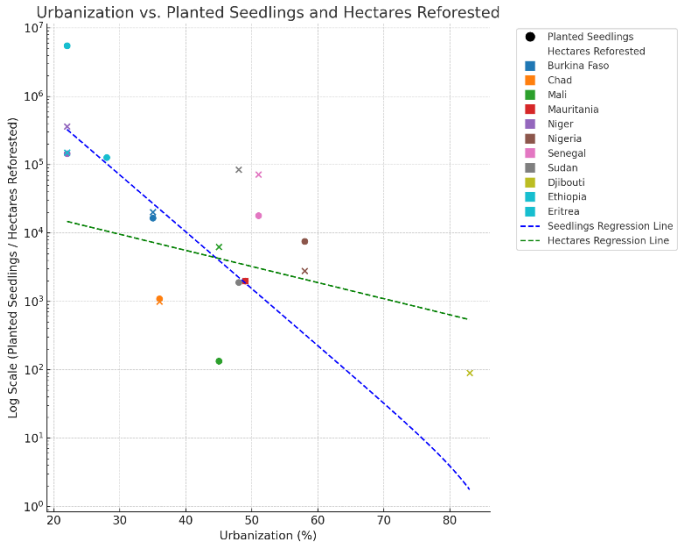

Figure 10 Scatterplot of Urbanization % per country & Planted seedlings, hectares reforested

Population density effect on Planted Seedlings and Reforested land.

Figures 11 and 12 show the relationship between population density (per km²) and the number of planted seedlings and hectares reforested in various countries involved in the Great Green Wall initiative. Contradictory to Zomer et al. (2008) there is no significant correlation. Moreover, Figure 12 shows 2 positive trend lines indicating a positive increase of Planted seedlings and Hectares Reforested with higher population densities. However, the analysis of population density and reforestation metrics reveals no statistically significant relationships. The Spearman correlation coefficient between population density and the number of planted seedlings is 0.418, with a p-value of 0.201, suggesting a moderate positive but non-significant relationship. Similarly, the correlation between population density and hectares reforested is weaker, with a coefficient of 0.218 and a p-value of 0.519, indicating no significant correlation. Therefore, population density does not appear to significantly influence either the number of planted seedlings or the hectares reforested.

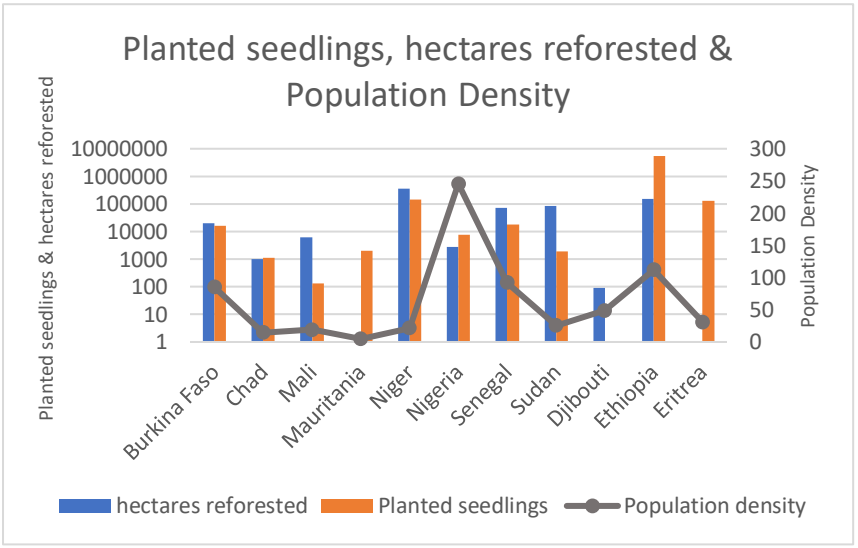

Figure 11 Planted seedlings, hectares reforested & Population density

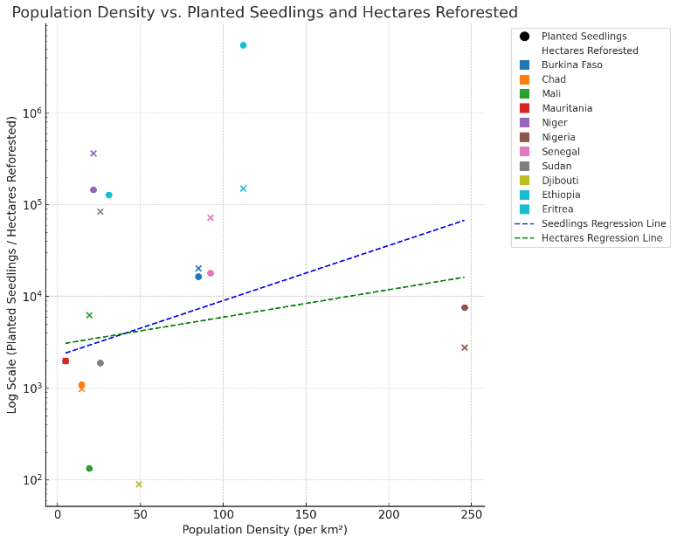

Figure 12 population density (per km²) and the number of planted seedlings and hectares reforested

What is the effect of HDI on Planted Seedlings and Reforested land.

The statistical analysis from Figure 13 and 14 did not reveal a significant correlation between the Human Development Index (HDI) and resilience enhancements among countries participating in the Great Green Wall project in the GGW intervention area. Despite variations in HDI scores across the region, there was no consistent pattern indicating a relationship between human development and the capacity to implement resilience strategies against desertification. While socioeconomic development is often considered a key determinant of resilience, the lack of a clear association with HDI underscores the complexity of resilience dynamics and the necessity for a more nuanced understanding of the underlying mechanisms. The weak negative correlations observed between HDI and both Planted Seedlings (Spearman correlation coefficient: -0.059, p-value: 0.863) and Hectares Reforested (Spearman correlation coefficient: -0.109, p-value: 0.781) further highlight this complexity. However, according to a study by Redo et al. (2012) in Central America, the HDI was the variable most correlated with total forest gain. The difference between these findings might be attributed to climate differences. Central America

predominantly consists of Af (Tropical rainforest), Am (Tropical monsoon), and Aw (Tropical savanna) climates, whereas the GGW intervention area is characterized by a BSh (Hot semi-arid) climate. This climatic variation could play a crucial role in the differing impacts of human development on resilience and forest gain between the regions.

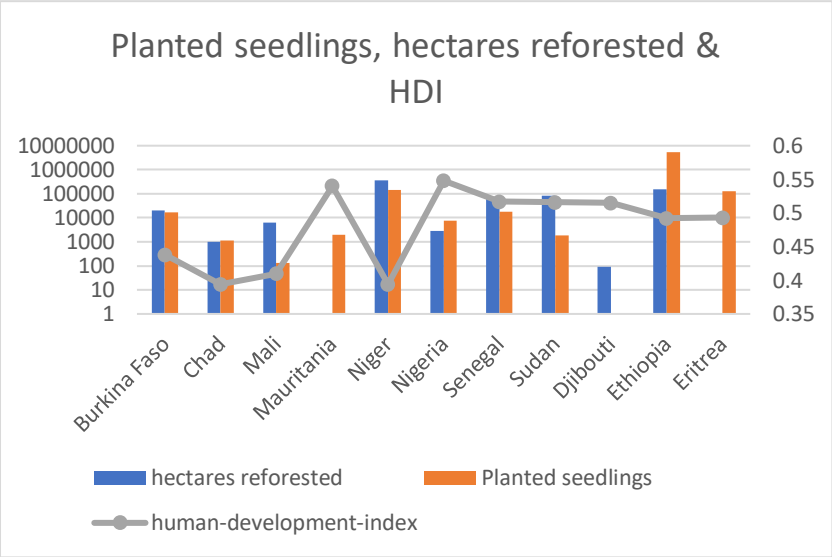

Figure 13 Planted seedlings, hectares reforested & HDI per country

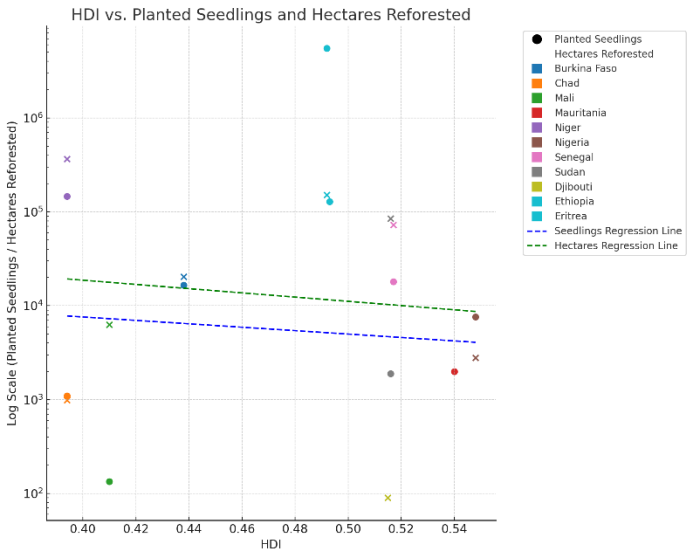

Figure 14 HDI and the number of planted seedlings and hectares reforested

GGW intervention area's effect on Planted Seedlings and Reforested land.

Figures 15 and 16 show the relationship between the GGW (Great Green Wall) intervention area and two key variables: the number of planted seedlings and the hectares reforested. The analysis reveals weak positive correlations between the GGW intervention area and both planted seedlings (Spearman correlation coefficient: 0.345, p-value: 0.298) and hectares reforested (Spearman correlation coefficient: 0.35, p-value: 0.356). These correlation coefficients indicate a slight tendency for larger GGW intervention areas to be associated with higher numbers of planted seedlings and greater hectares reforested. However, the p-values suggest that these correlations are not statistically significant, meaning that the observed relationships could be due to random chance rather than a true underlying association. As Akhtar-Schuster et al. (2010) note that The UNCCD's Global Mechanism (GM) suggests that funding strategies to reduce land degradation and promote sustainable land management (SLM) should be tailored to fit each country's specific environmental, political, economic, and institutional situation, and therefore, not only on size

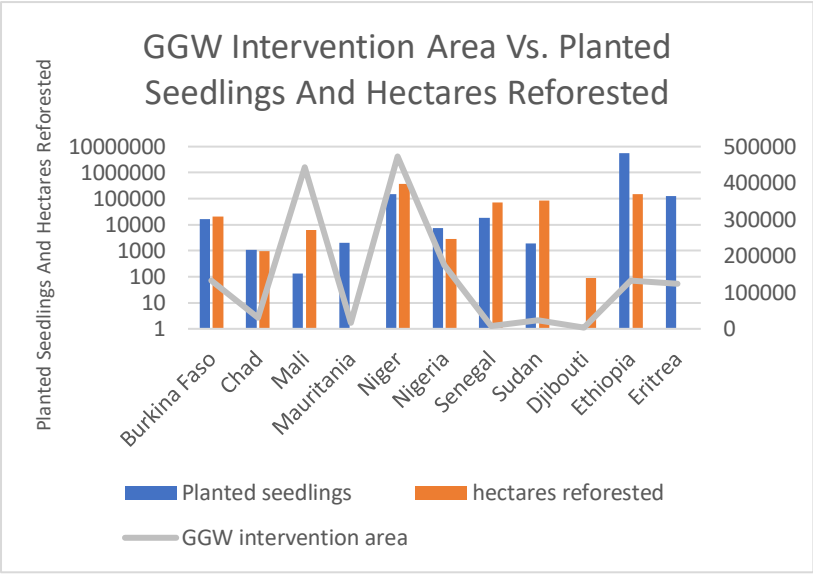

Figure 15 Planted seedlings, hectares reforested & GGW Intervention Area

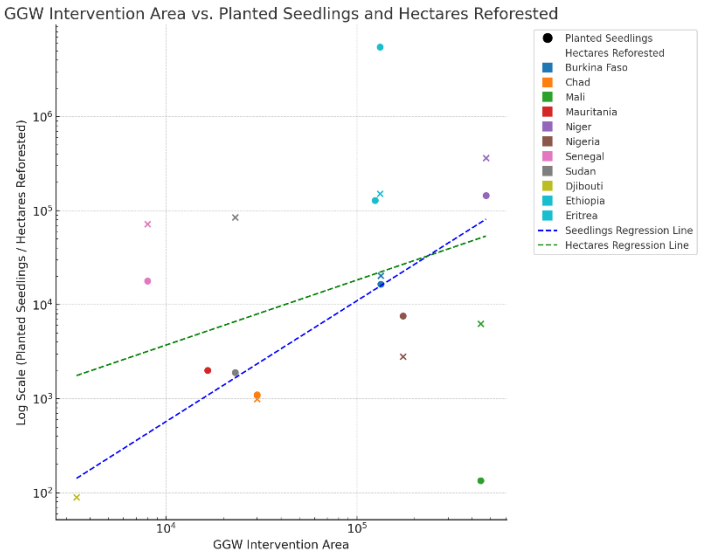

Figure 16 GGW Intervention Area and the number of planted seedlings and hectares reforested

The effect of GGW Budget on Planted Seedlings and Reforested land.

Figure 17 shows the GGW budget against the Planted Seedlings and Reforested land. The results from the spearman rank test indicate a very weak negative correlation (-0.096, p-value: 0.779) between the GGW budget and the number of planted seedlings, and a weak positive correlation (0.387, p-value: 0.304) between the GGW budget and hectares reforested. However, the p-values suggest that these correlations are not statistically significant, indicating that the observed relationships could be due to random chance rather than a true underlying condition. Figure 18 shows illustrate the relationship between the GGW intervention area and the price per reforested land for the countries involved in the

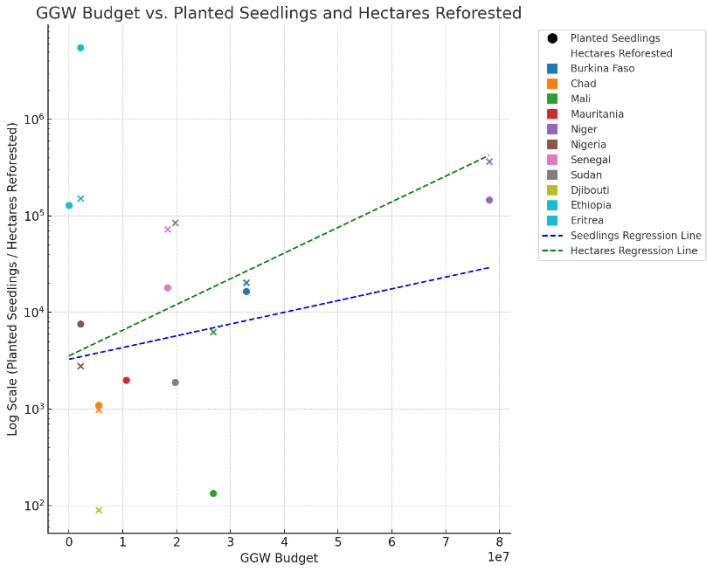

Figure 17 GGW Budget and the number of planted seedlings and hectares reforested

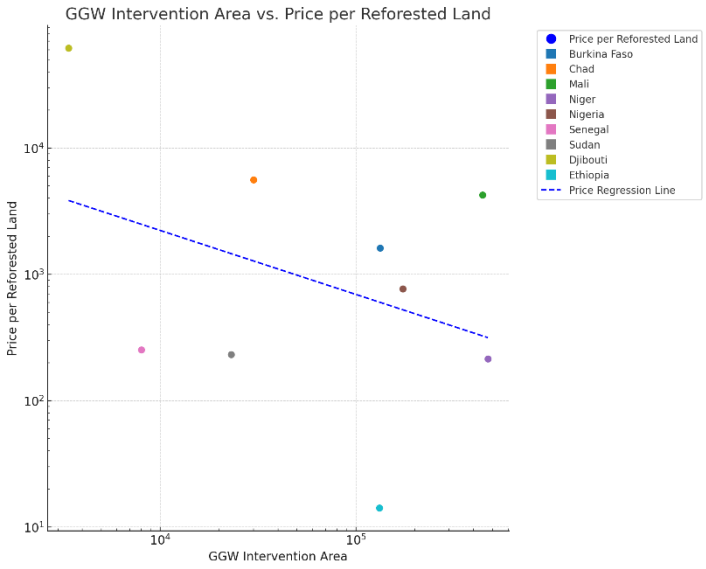

Figure 18 illustrates the relationship between the GGW intervention area and the price per reforested land for the countries involved in the Great Green Wall project.

Great Green Wall project. According to Andres et al. (2024) the price drops with more hectares being planted. The regression line suggests a weak negative trend, consistent with the calculated Spearman correlation coefficient and the prior source. However the Spearman correlation test indicated a weak negative correlation (-0.283) between the GGW intervention area and the price per reforested land, though this correlation was not statistically significant (p-value: 0.460).

How does joining international projects have an effect on Planted Seedlings and Reforested land.

Figure 19 shows us there seems to be an association between the number of international projects joined and planted Seedlings and reforested land. From Figure 20 can see there is a positive regression line supporting the association from Figure 19. However, the results from the spear man rank test indicate that there is a moderate positive correlation between the number of international projects and both planted seedlings and hectares reforested. However, the p-values suggest that these correlations are not statistically significant, although they are closer to significance compared to previous analyses. This means that while there is a tendency for more international projects to be associated with more planted seedlings and larger areas reforested. Which was mentioned in Kim and Doerfel (2024) and Yamoah et al. (2020) which concluded that partnerships are crucial for advancing sustainable initiatives. The observed relationships could still be due to random chance rather than a true underlying association.

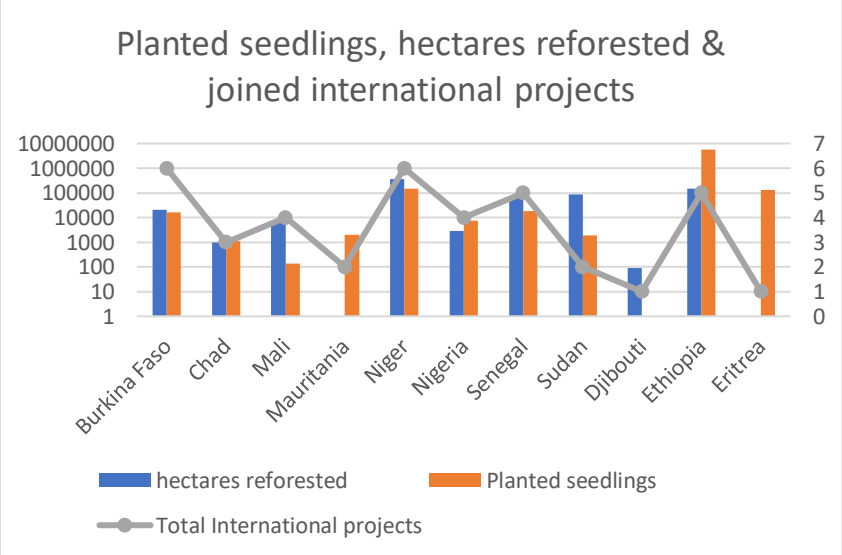

Figure 19 Planted seedlings, hectares reforested & joined international projects per country

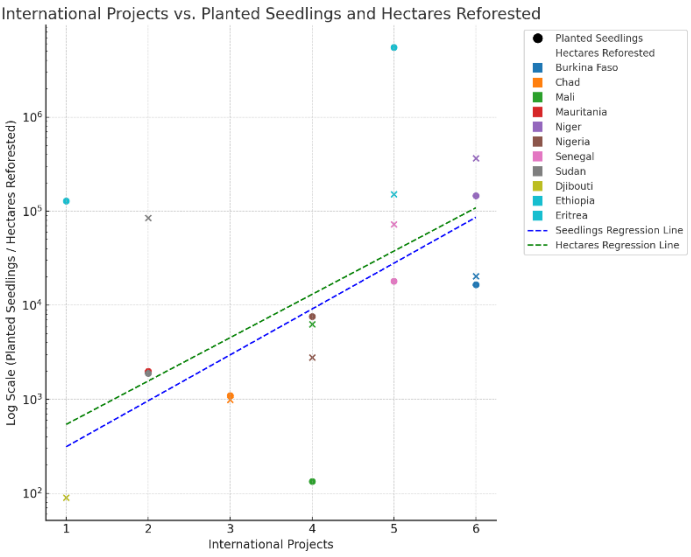

Figure 20 International projects joined and the number of planted seedlings and hectares reforested

How do national policies impact the implementation of resilience improvements in countries within the GGW intervention area.

National policies and governance frameworks are crucial in shaping the implementation of resilience improvements in GGW intervention area countries (Fraser & Kirbyshire, 2017). They provide the necessary regulatory framework, institutional support, and resource allocation to address environmental challenges like desertification and enhance resilience (Deininger et al., 2014). In each country, the effectiveness of national policies and governance frameworks depends on factors such as political commitment, institutional capacity, stakeholder engagement, and resource availability (Fraser & Kirbyshire, 2017). Strong political will and leadership are essential for prioritizing resilience-building efforts and integrating them into national development agendas. Additionally, effective governance structures and institutions are necessary to coordinate and monitor the implementation of policies and programs aimed at combating desertification (Prince, 2016).

	Politicalsystem	**Political system %score**
Burkina Faso	Coup	27
Chad	Coup	15
Mali	Coup	26
Mauritania	HybridRegime	39
Niger	Coup	33
Nigeria	HybridRegime	44
Senegal	HybridRegime	67
Sudan	Coup	6
Djibouti	Authoritarian	24
Ethiopia	Authoritarian	20
Eritrea	Authoritarian	3

Table 1 Political system per country and freedom % (Freedom House, n.d.)

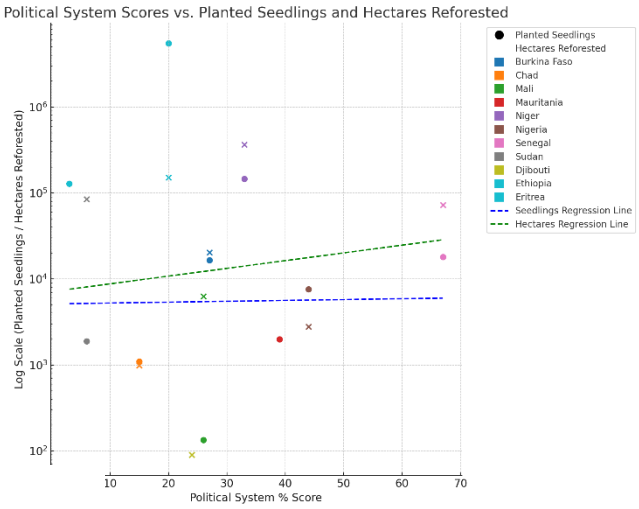

Figure 21 relationship between political system scores and both planted seedlings and hectares reforested for each country

In (table 2) we can see the different countries and their current (as of May 2024) political system. Also depicted in (table 2) is the political freedom score this rating measures a country's political freedom, commitment to democracy, legal system integrity, and overall governance. Higher ratings indicate more political liberties and better governance, while lower ratings suggest limitations on freedoms and governance challenges. Figure 21 does not really show any association between planted seedlings and hectares of reforested. Only a slight positive regression between hectares reforested and political freedom score. The analysis of the political system score versus planted seedlings and hectares reforested shows very weak positive correlations between the political system score and both planted seedlings (Spearman correlation coefficient: 0.118, p-value: 0.729) and hectares reforested (Spearman correlation coefficient: 0.083, p-value: 0.831).

Obstacles and difficulties countries encounter in implementing resilience measures.

Countries have reported various difficulties they faced while implementing the GGW Strategy and Action Plans (United Nations Convention to Combat Desertification, 2020), including obstacles directly related to the Initiative itself, as well as challenges associated with sustainable soil management and the restoration of degraded land more broadly such as:

- Funding
- Governance
- Monitoring and reporting
- Technical (in relation to restoration projects)

The difficulties of these countries are shown in table x where a red marker indicates the difficulties per country.

County	Governance	Monitoring & reporting	Financial	Technical capabilities
Burkina Faso				
Chad				
Mali				
Mauritania				
Niger				
Nigeria				
Senegal				
Sudan				
Djibouti				
Ethiopia				
Eritrea				

Table 3 Challenges encountered by countries

The lack of high-level political support for the environmental policy agenda has resulted in insufficient legislation and institutional structures to support the GGW. Weak organizational structures and lack of resources have hindered environmental projects, while political instability affects implementation. Coordination with other sectors is lacking, making it challenging to endorse a "landscape approach" and integrate environmental management practices into sector strategies. Additionally, there is a need for better knowledge sharing and collaboration at both national and regional levels (Neely, 2022).

Challenges in the Measurement Reporting and Verification system for the Great Green Wall Initiative include a lack of monitoring and evaluation expertise and inadequate funding for MRV capacities. This hinders effective implementation and reduces credibility with funders. Additionally, there are issues with project management structures at various levels leading to deficiencies in implementation and financial allocation. Difficulty in mobilizing allocated funds further complicates monitoring activities at the local level (United Nations Convention to Combat Desertification, 2020).

In Neely's (2022) work, a major issue that was addressed is the insufficient financial support for partnerships, as it is not typically included in traditional funding allocations. Additionally, the working group emphasized the necessity for increased involvement at the national level to take apart the barriers that prohibit effective communication and coordination.

Investors consider political and country risks, encompassing social, political, and economic circumstances and occurrences that could jeopardize investment performance and profitability. When assessing opportunities abroad, such as the GGW Initiative in the Sahel,

investors may be deterred by the potential risks arising from host government actions or other political developments within a country. Presently, most GGW countries exhibit significant to severe country risks, as reported by EEX Africa in 2020 and shown in (table 3) (United Nations Convention to Combat Desertification, 2020).

5. Conclusion and Discussion

5.1 Conclusion

This study explored the factors that influence resilience enhancements in the countries participating in the Great Green Wall (GGW) initiative. Through a comprehensive analysis using the Spearman correlation test on secondary data, several key findings were identified that address the main research question and its secondary questions.

The analysis revealed that funding levels and international collaboration significantly boost reforestation efforts and resilience. Countries with lower urbanization rates and active participation in international projects tend to show higher resilience enhancements. Contrary to expectations, HDI did not show a clear correlation with resilience improvements, suggesting the need for a nuanced understanding of resilience dynamics. Governance and political stability emerged as critical factors, with countries having stronger governance structures and higher levels of political freedom achieving better resilience outcomes.

National policies and governance frameworks are crucial in shaping the implementation of resilience improvements. Effective governance structures and political stability are essential for the successful implementation of GGW initiatives. Countries with stable political environments and strong governance frameworks seem to have more consistent policies and better support for resilience projects, leading to more significant and sustainable impacts on land restoration and community development.

Although this study primarily focused on statistical data, it is evident from the literature that traditional knowledge and local community involvement play a significant role in the success of resilience-enhancing initiatives. Communities with a strong understanding of local environmental conditions and practices are better equipped to implement effective land management and reforestation strategies. Engaging local communities in the planning and execution of GGW projects enhances their ownership and ensures the sustainability of these initiatives.

Socio-economic factors, particularly resource accessibility and poverty levels, significantly impact the effectiveness of resilience enhancements. The study shows that countries with higher resource accessibility and lower poverty levels are better able to implement and sustain reforestation efforts. Financial resources are critical because adequate funding enables the procurement of necessary materials and labor for large-scale reforestation projects. However, the direct impact of HDI on resilience was not significant, indicating that other factors such as specific resource allocation and governance play more decisive roles.

Several obstacles and difficulties were identified, including inadequate funding, weak monitoring and reporting systems, and technical limitations. Political instability and governance challenges further exacerbate these issues. Countries experiencing political turmoil, such as coups or civil unrest, face significant challenges in maintaining consistent and effective resilience measures. Additionally, the variability in resource allocation and

infrastructural support across different countries creates disparities in the effectiveness of resilience enhancements.

5.2 Discussion

The findings of this study provide crucial insights into the complex nature of resilience enhancements in the GGW intervention area. The significant role of funding and international collaboration underscores the necessity for sustained financial and technical support from the global community. The observed positive impact of lower urbanization rates on reforestation efforts highlights the potential benefits of focusing on rural areas where land is more readily available for large-scale environmental projects.

The unexpected lack of correlation between HDI and resilience improvements suggests that traditional socioeconomic indicators may not fully capture the complexities of resilience dynamics in the context of environmental restoration and sustainable development.

The study faced several limitations, including reliance on secondary data, which may introduce biases or inaccuracies inherent in the original sources. To mitigate this, data was cross-referenced with multiple credible sources such as the United Nations and World Bank to ensure robustness and reliability. The variability in data quality and availability across different countries in the GGW intervention area was addressed using standardized statistical methods such as the Spearman correlation test to analyze the data. Additionally, the complex interaction of political, social, and environmental factors influencing resilience enhancements needed a nuanced analysis. While this study primarily employed statistical methods, future research should consider integrating qualitative approaches to capture these complex interactions more comprehensively.

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